

# RHIC Status and Plans

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Brief summary of RHIC RUN2001/2

Plans and goals for RUN2003

# FY2001 - 02 RHIC Gold Parameters

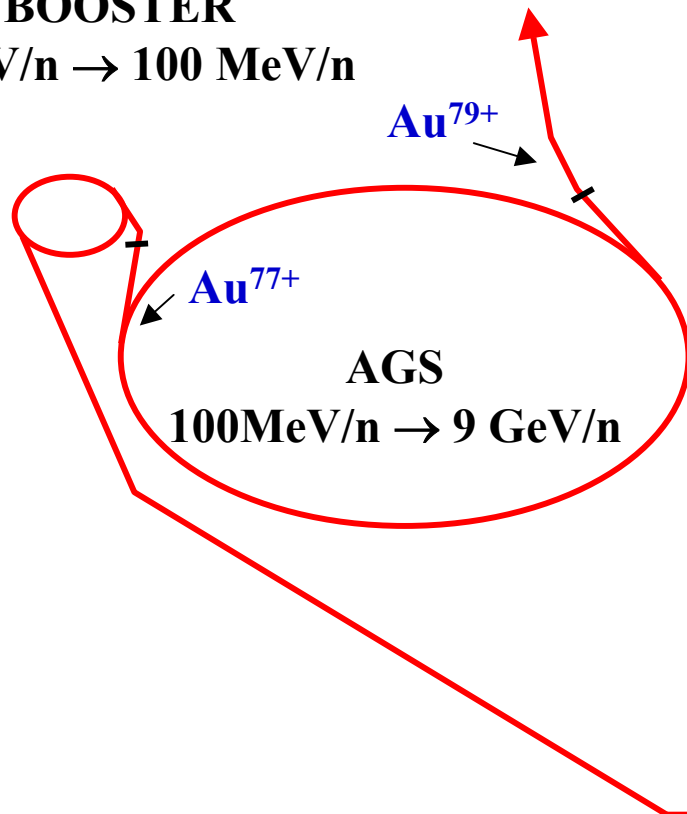
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- **55 - 56 bunches** per ring ✓ (110 bunches per ring tested, intensity limited)
- **$7.5 \times 10^8$  Au/bunch @ storage energy** (intensity limited during acceleration)
- **$1 \times 10^9$  Au/bunch achieved @ injection** ✓
- **Longitudinal emittance:** 0.5 eVs/nucleon/bunch (0.3-0.6 Design) ✓
- **Transverse emittance at storage:**  $15 \pi \mu\text{m}$  (norm, 95%) ✓
- **Storage energy:** 100 GeV/ amu ( $\gamma = 107.4$ ) ✓ 10 GeV / amu ( $\gamma=10.5$ ) ✓
- **Lattice with  $\beta^*$  squeeze during acceleration ramp:**
  - $\beta^* = 3 \text{ m}$  and  $10\text{m}$  @ all IP at injection ✓
  - $\beta^* = 1 \text{ m}$  @ 8 and  $2 \text{ m}$  @ 2, 6 and 10 o'clock at storage ✓
- **Peak Luminosity:**  $5 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$  ( $2.5 \times$  design average) ✓
- **Bunch length:** 5ns (200 Mhz operational, diamond length:  $\sigma = 20 \text{ cm}$ ) ✓

# Au Injector Performance (needs update)

## BOOSTER

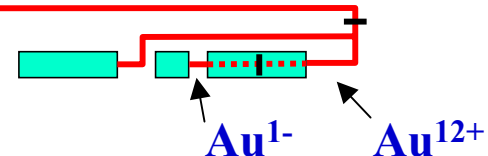
1 MeV/n  $\rightarrow$  100 MeV/n



	<u>Intensity/RHIC bunch</u>	<u>Efficiency</u>
Tandem	$(3.8) \times 10^9$	
Booster Inj.	$(2.2) \times 10^9$	58%
Booster Extr.	$(1.8) \times 10^9$	81%
AGS Inj.	$(0.9) \times 10^9$	50%
AGS Extr.	$1.2(0.9) \times 10^9$	<u>95%</u>
Total		23%

Au<sup>32+</sup> : 1.1 part.  $\mu$ A, 530  $\mu$ s ( 40 Booster turns)

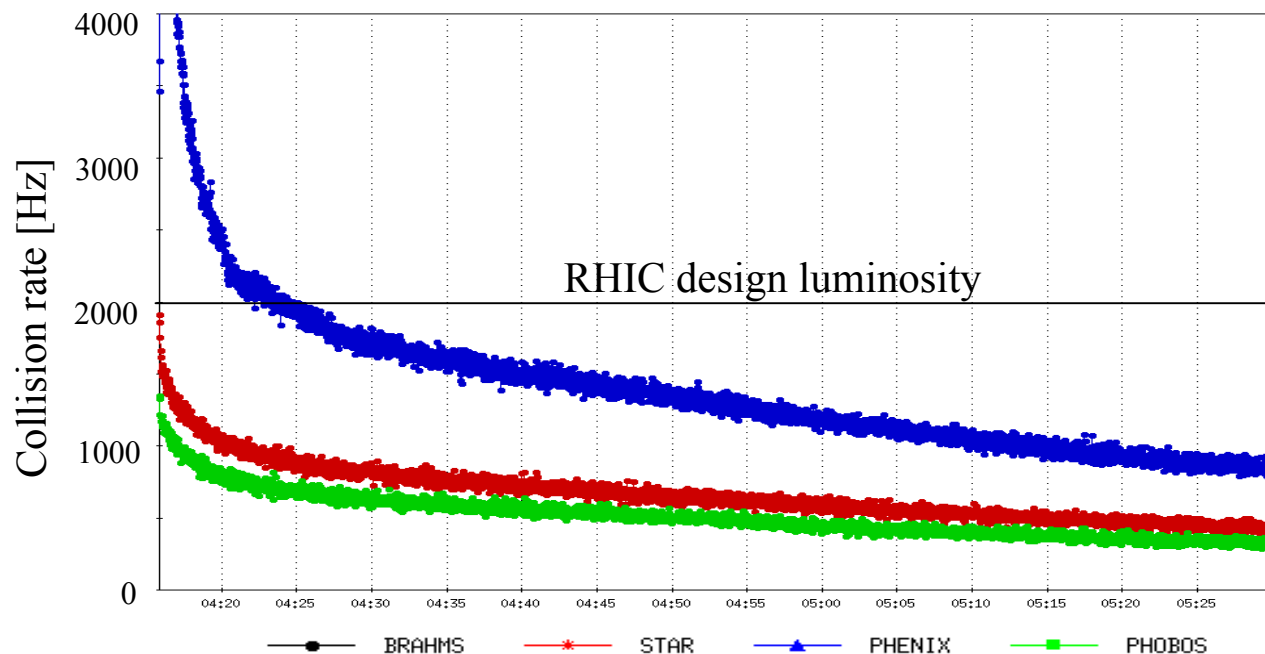
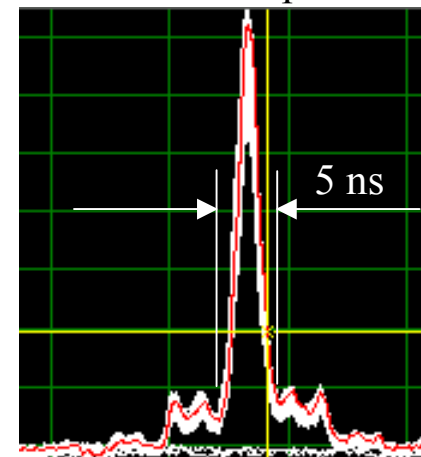
TANDEMS



# RHIC performance

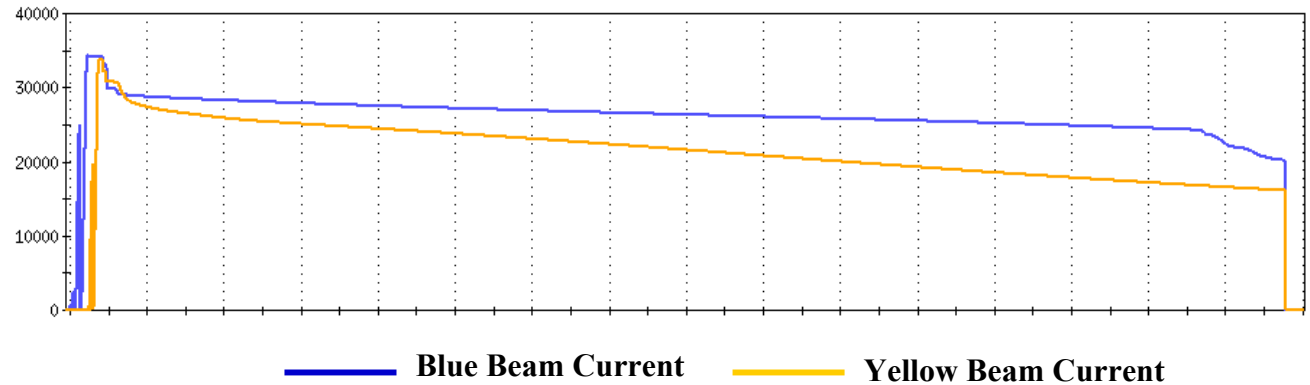
- Collisions at RHIC design beam energy (100 GeV/nuc)
- 200 MHz rf system operational
  - 5 ns bunch length and an interaction region with  $\sigma \sim 25$  cm
- Luminosity exceeding RHIC design luminosity of  $2 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$
- 40% availability is limiting total integrated luminosity

RHIC bunch profile

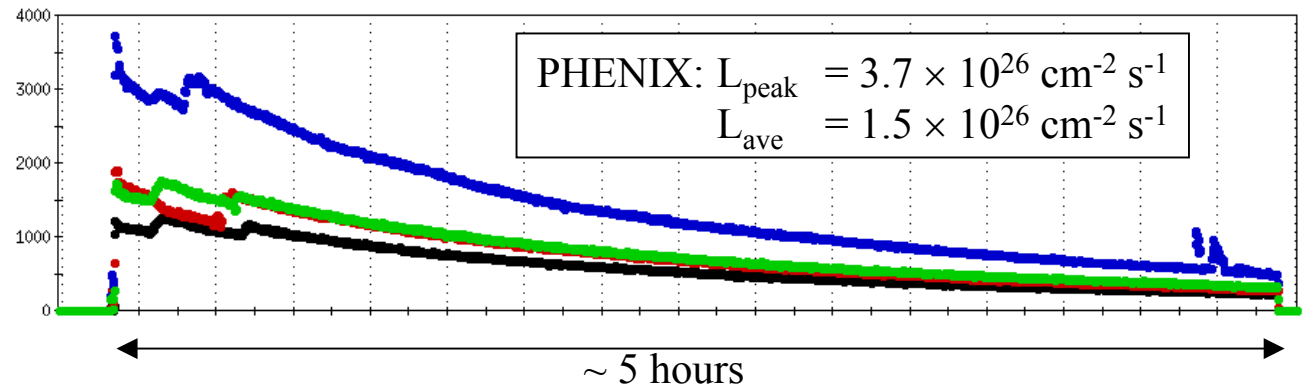


# “Typical Store” # 1812

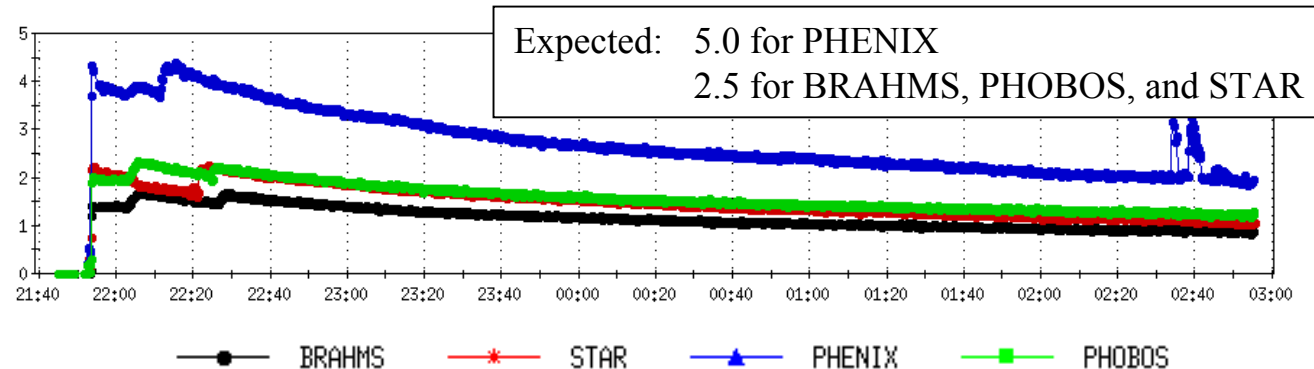
Beam currents [ $\times 10^6$  ions]



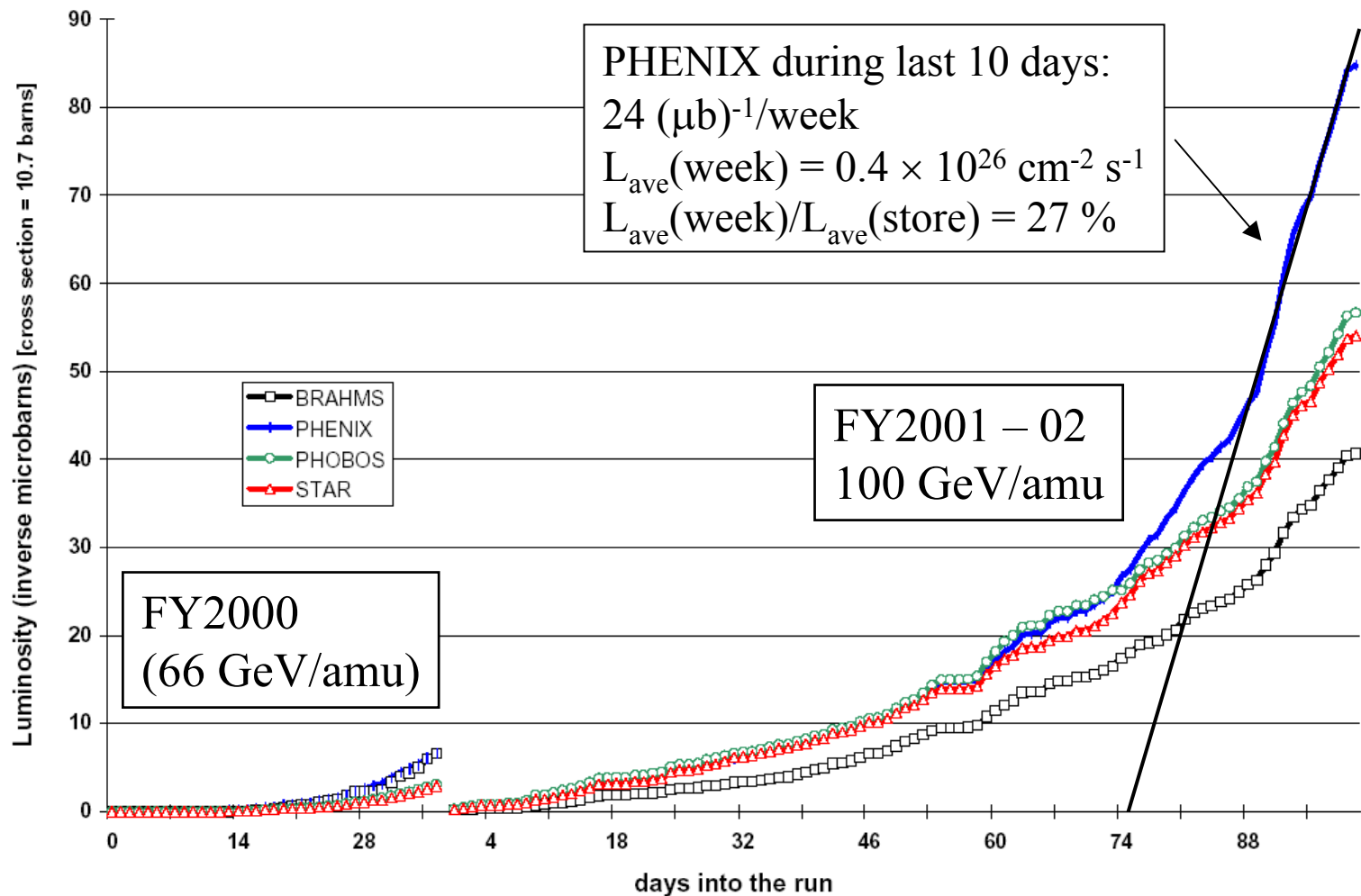
Collision rate [Hz]



Specific luminosity [Hz/10]

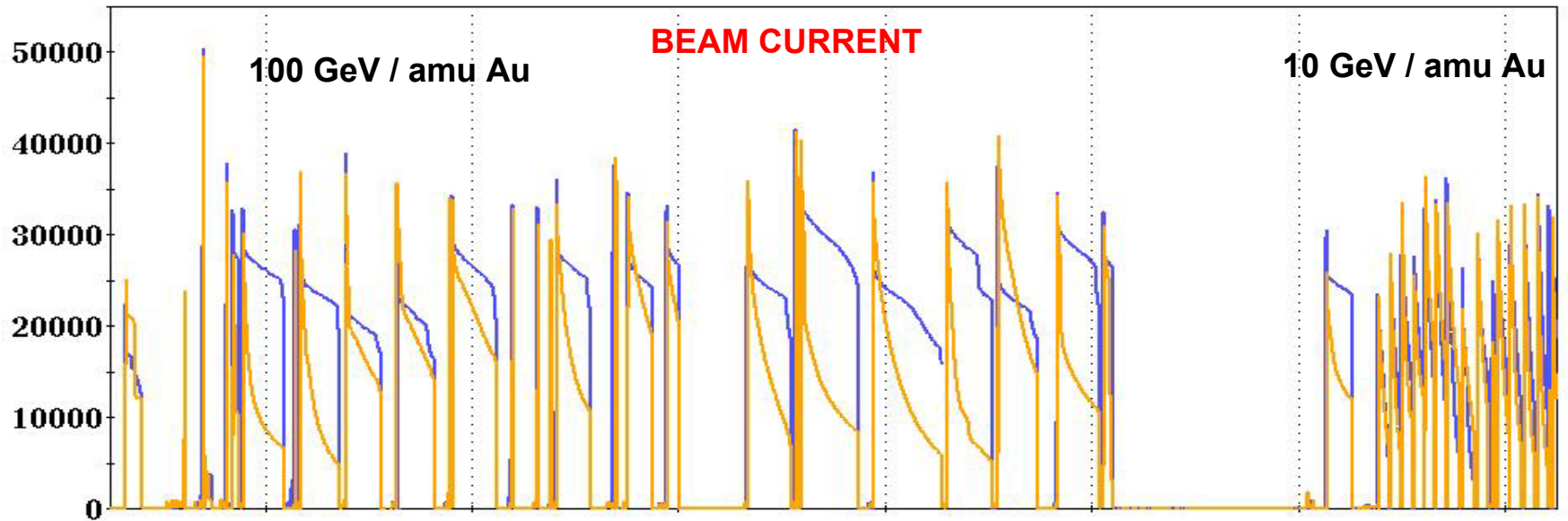


# Integrated Au-Au luminosity



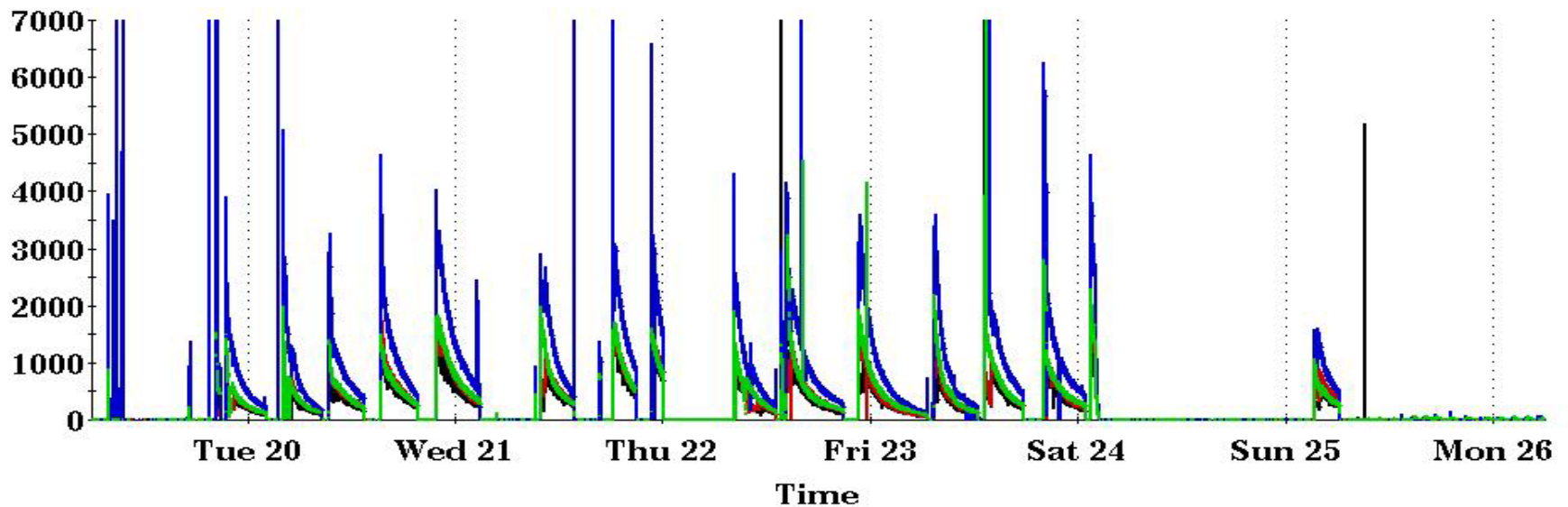
# RHIC PERFORMANCE

$\times 10^6$  Au



$\times 10^{23} \text{ cm}^{-2} \text{ sec}^{-1}$

**LUMINOSITY**



# RHIC Au commissioning and challenges

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- Single- and multi-bunch instabilities
  - Effect of vacuum chamber impedance, electron cloud (?)
- Intensity limitation for gold (?) due to vacuum break-down
  - Limited to about  $40 \times 10^9$  Au/ring
    - Electron cloud ? Ion or electron desorption ?
- Intra-Beam Scattering (IBS)
  - Transverse and longitudinal emittance growth
  - Eventually will need electron cooling (see below)
- Beam-beam tune shift and spread
  - First strong-strong hadron collider (after ISR)



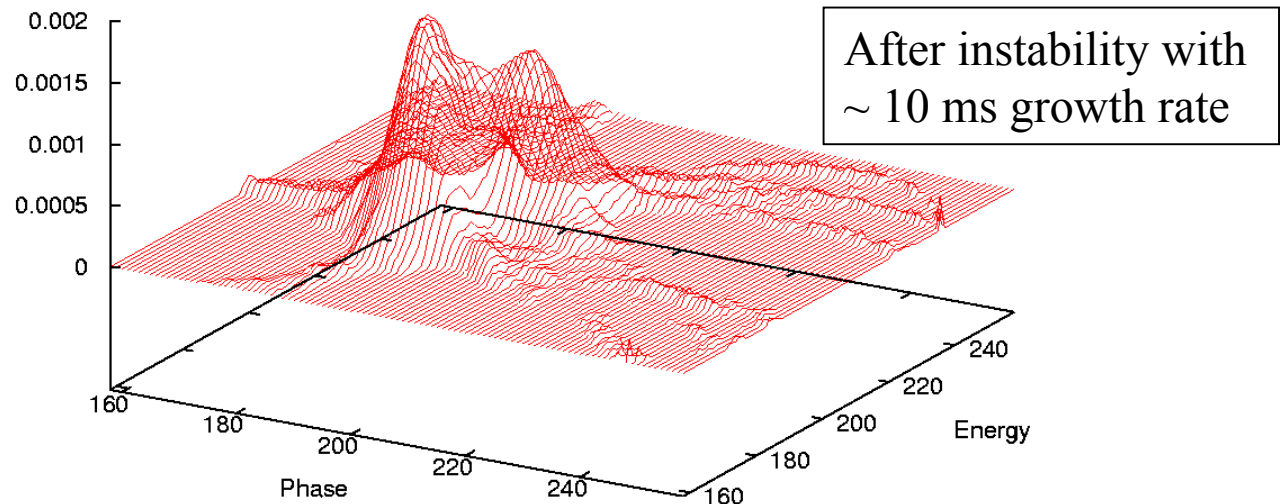
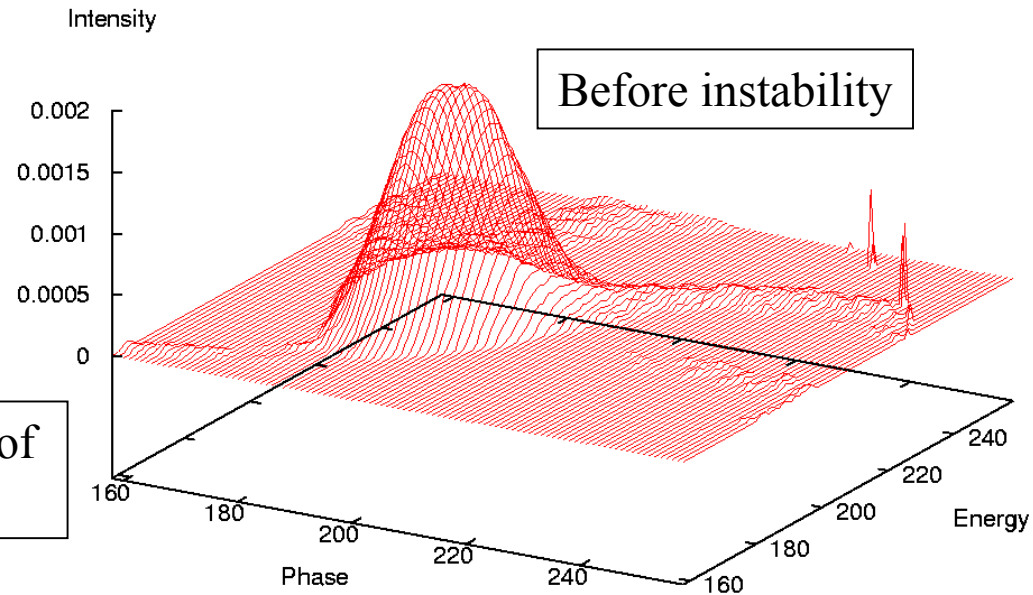
# Transverse instabilities in RHIC

High sensitivity around transition

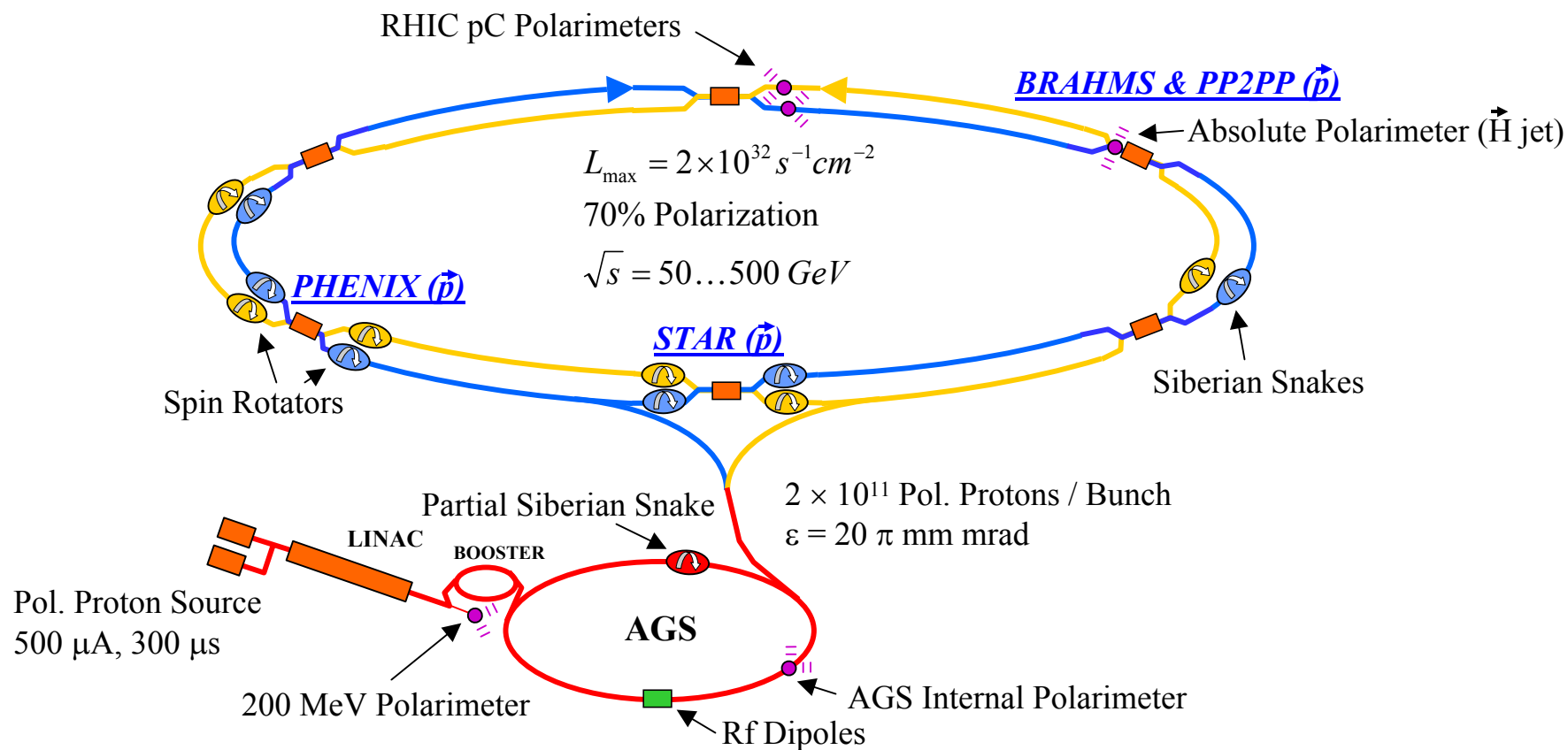
Effect of vacuum chamber impedance, electron cloud (?)

Cures: beam-beam tune spread, **octupoles**, transverse dampers, rf quad, ...

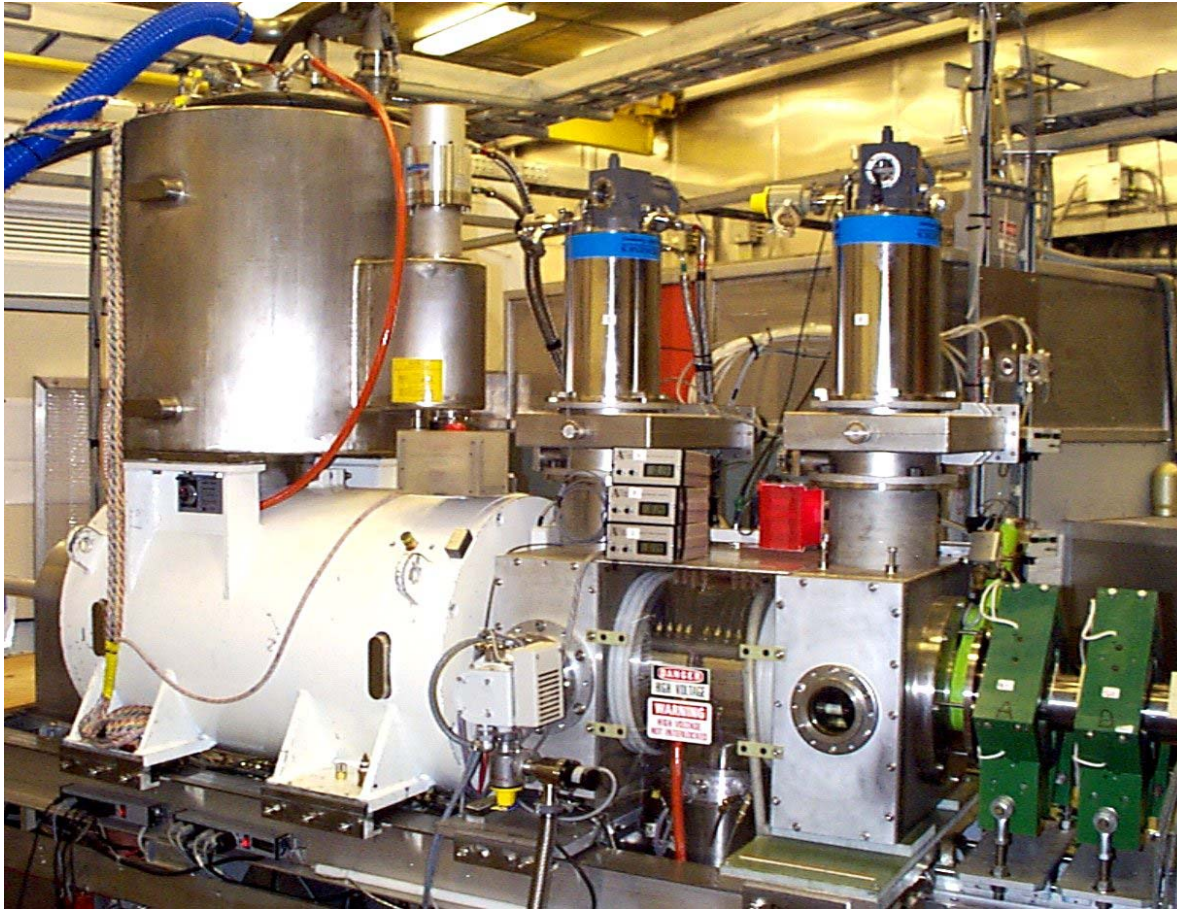
Tomographic reconstruction of 2D bunch density



# Polarized proton collisions in RHIC



# High intensity polarized $H^-$ source



KEK OPPIS  
upgraded at TRIUMF

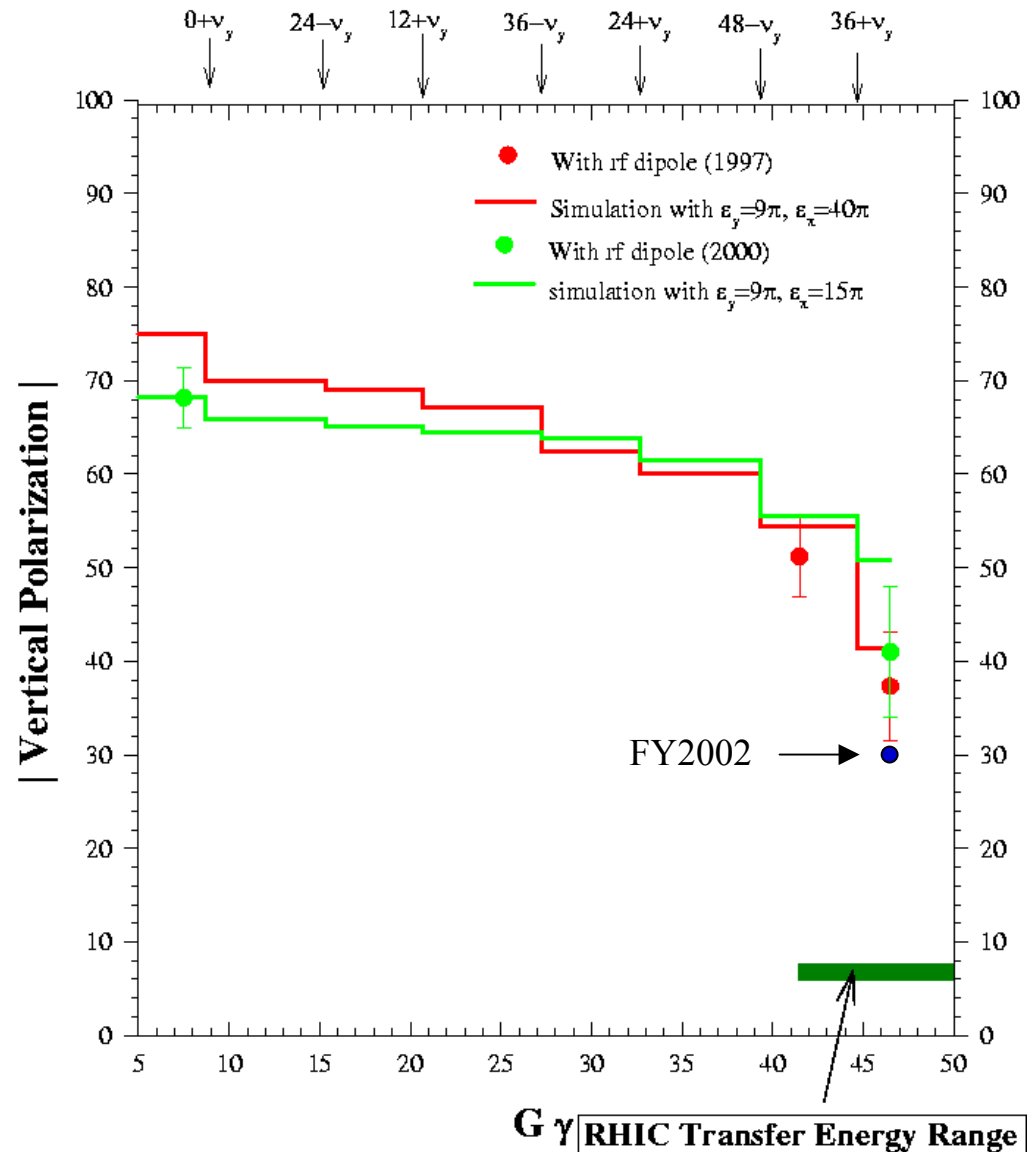
70 - 80 % Polarization

$15 \times 10^{11}$  protons/pulse  
at source

$6 \times 10^{11}$  protons/pulse  
at end of LINAC

# Proton polarization at the AGS

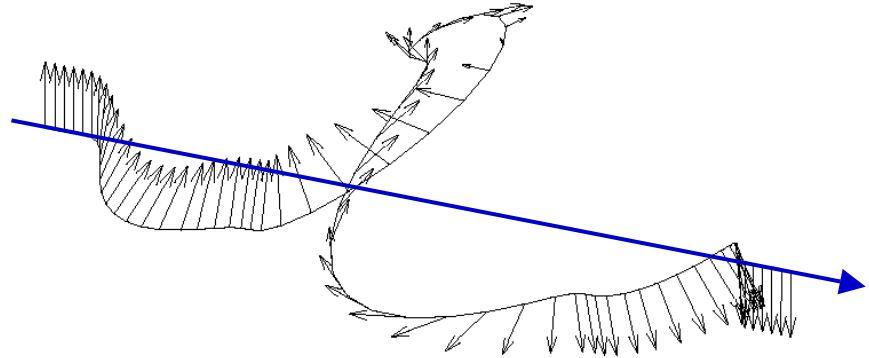
- Full spin flip at all imperfection resonances using partial Siberian snake
- Full spin flip at strong intrinsic resonances using rf dipole
- Remaining polarization loss from coupling and weak intrinsic resonances
- Larger polarization loss in FY2002 due to lower ramp-rate motor-generator and higher bunch intensity (?)



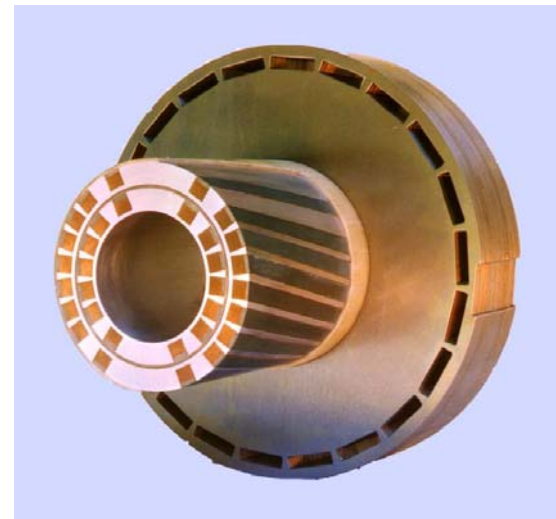


# First Siberian Snake in RHIC Tunnel

Siberian Snake: 4 superconducting helical dipoles, 4 Tesla,  
2.4 m long with full  $360^\circ$  twist

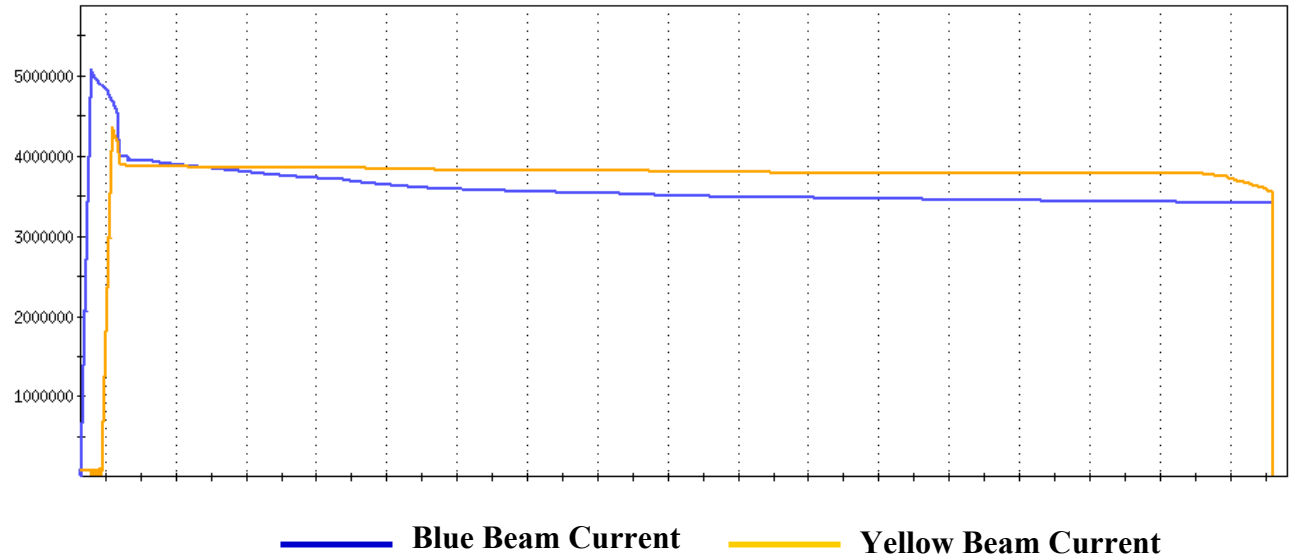


Funded by RIKEN, Japan  
Designed and constructed at BNL

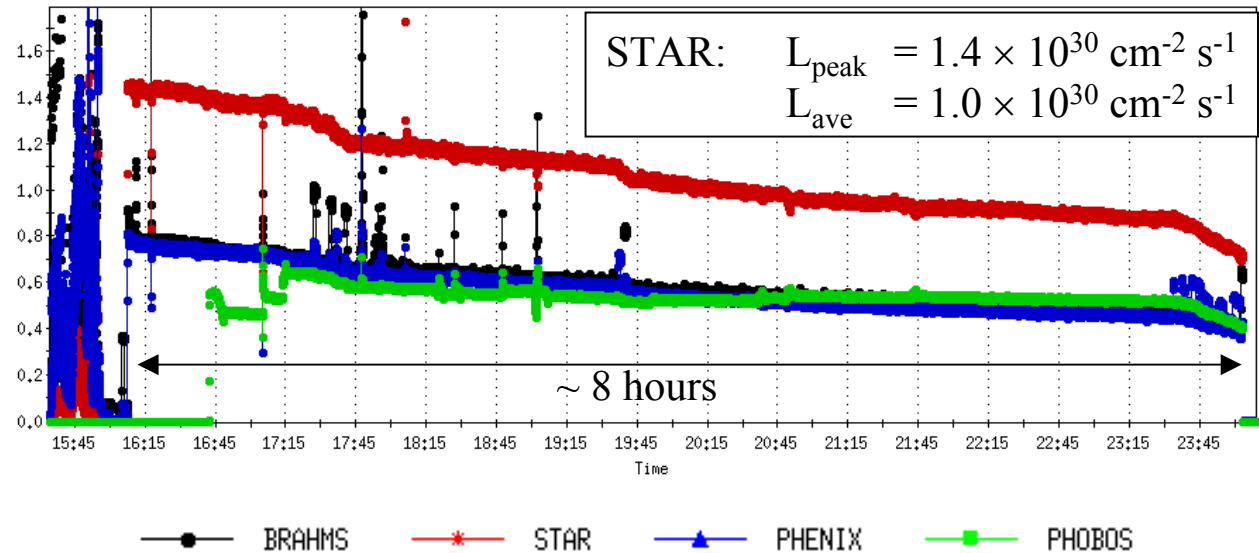


# “Typical Store” # 2304

Beam currents [ $\times 10^6$  ions]



Luminosity [ $\times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$ ]



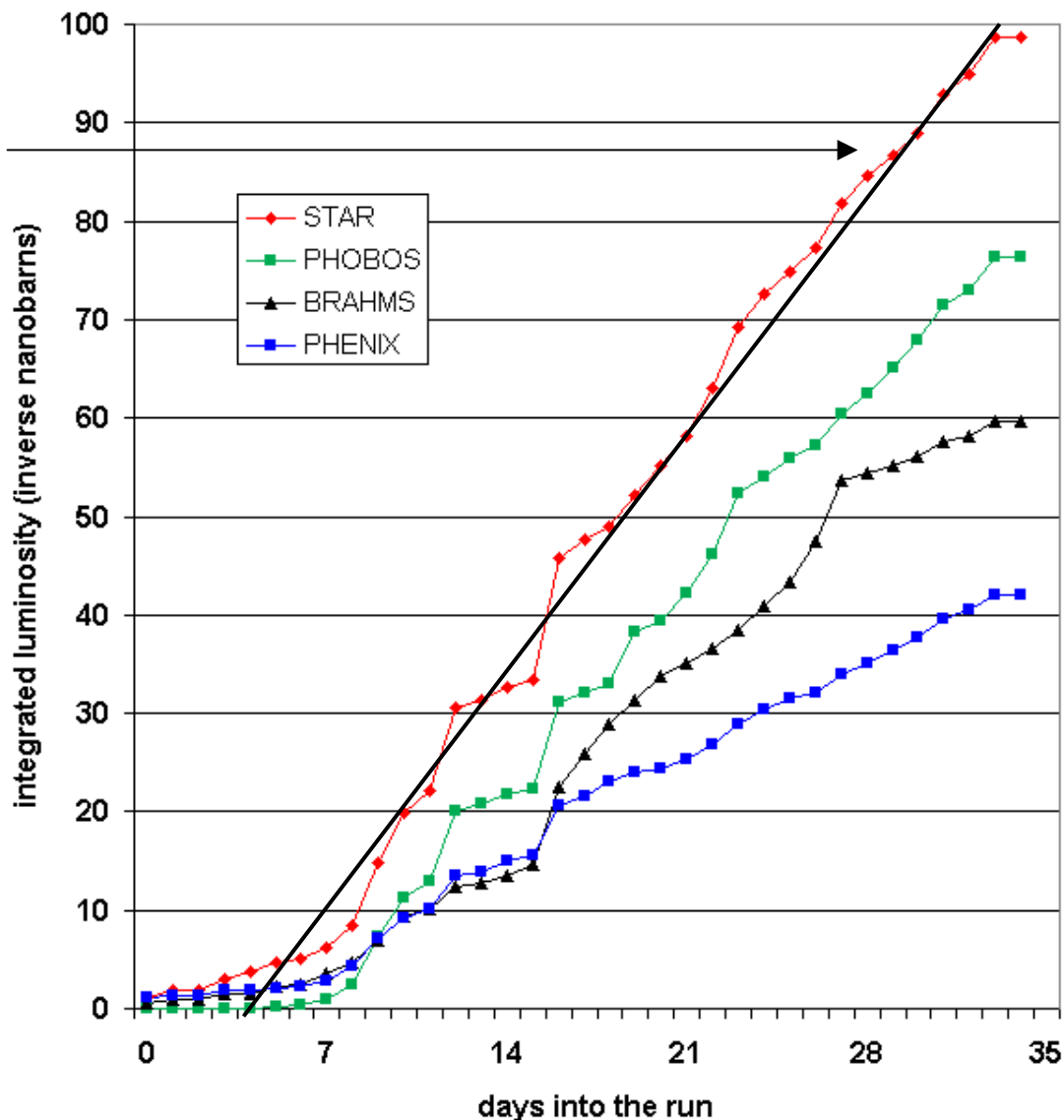
# Integrated p - p luminosity (numbers wrong?)

STAR during last 25 days:

$24 \text{ (nb)}^{-1}/\text{week}$

$L_{\text{ave}}(\text{week}) = 0.4 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$

$L_{\text{ave}}(\text{week})/L_{\text{ave}}(\text{store}) = 4 \%$



# Results from first RHIC polarized proton run

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- 55 bunches per ring with  $0.8 \times 10^{11}$  p $\uparrow$ /bunch
- Charge/bunch and total charge higher than with gold beams
- Lattice with constant  $\beta^*$  of 3 m during ramp
- Peak luminosity at beginning of store:  $1.5 \times 10^{30}$  cm $^{-2}$  s $^{-1}$
- Energy/beam: 100 GeV
- Beam polarization  $\sim 25$  %  
**RHIC polarimeters work reliably**
- Little if any depolarization in RHIC during acceleration and store  
**Siberian Snakes work**
- $\sim 60$  % polarization loss in AGS; aggravated by lower ramp-rate from Westinghouse motor-generator
- **Strong Siberian snake in AGS ( $\sim 30$  % of full snake) could avoid all depolarization in the AGS**

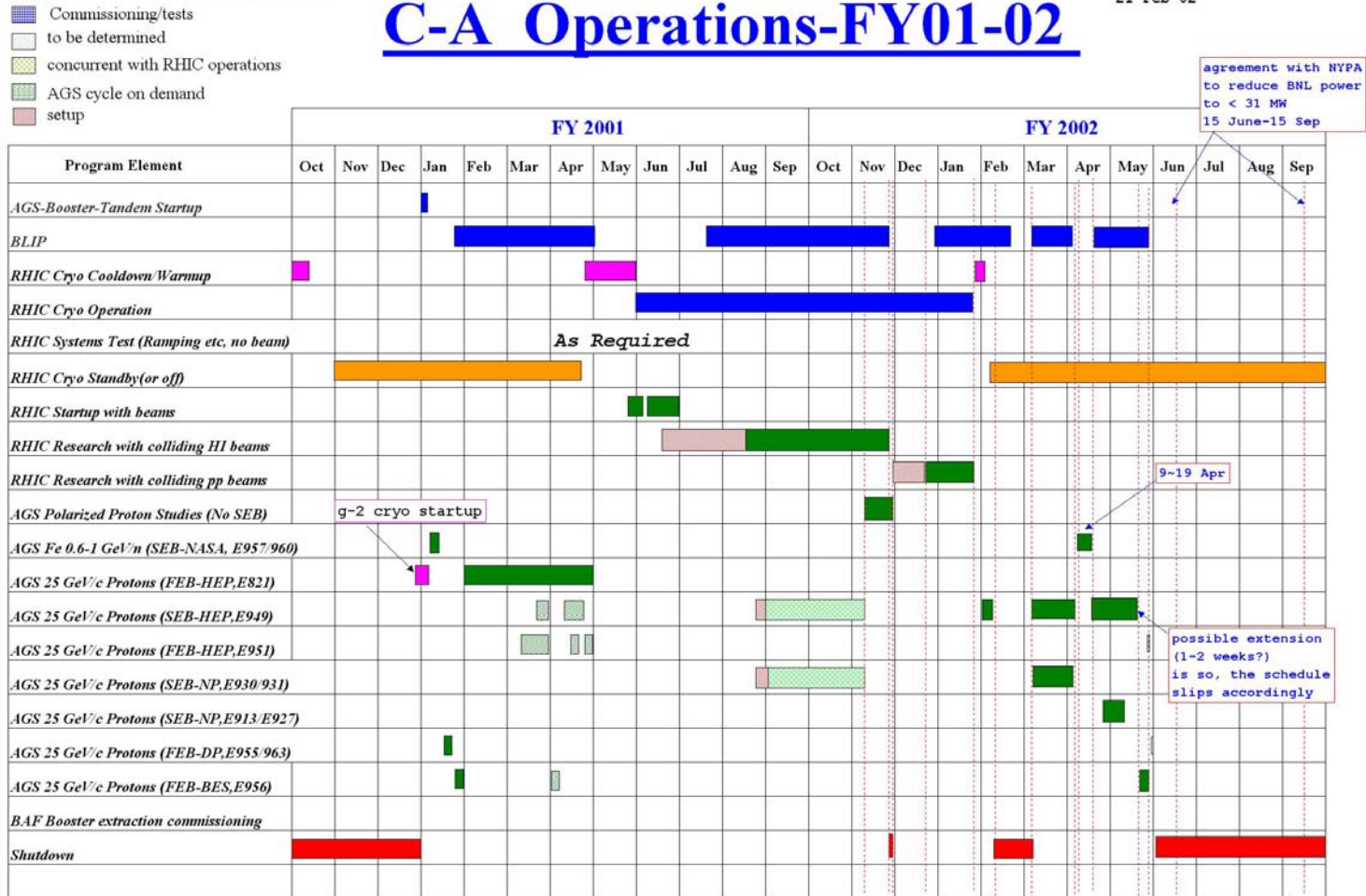


# C-A Operation FY20001-02

<http://server.c-ad.bnl.gov/esfd>

## C-A Operations-FY01-02






21 Feb 02



# C-A Operation FY2003-04

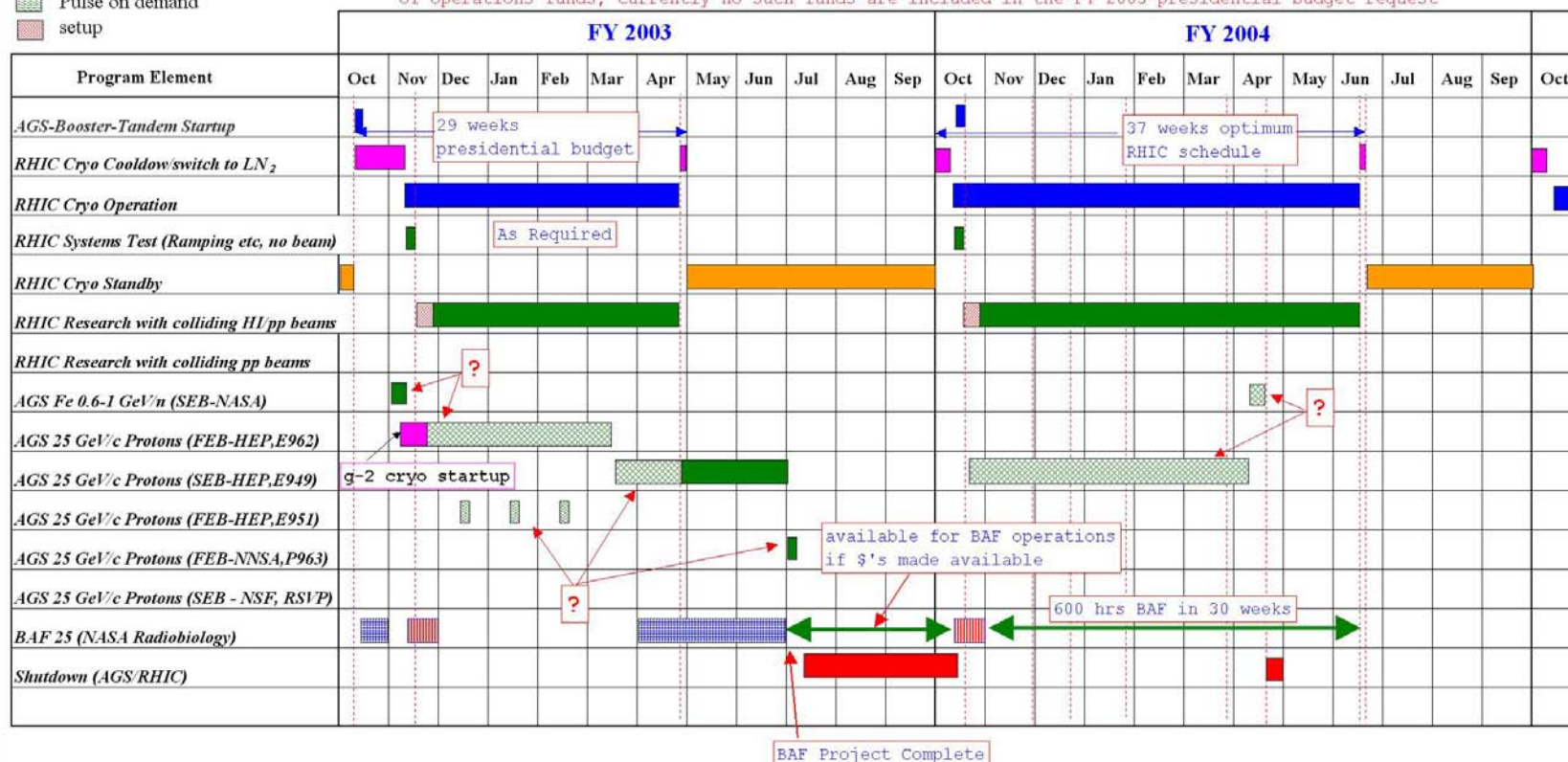
<http://server.c-ad.bnl.gov/esfd>

14 Feb 02

-  BAF/SEB/FEB operation blackout
-  Concurrent with RHIC operations
-  Commissioning
-  Pulse on demand
-  setup

## C-A Operations-FY03-04

subject to funding etc. AGS fixed target experiments (FEB and SEB) are contingent upon restoration of operations funds, currently no such funds are included in the FY 2003 presidential budget request



# RUN2002 Goals

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- Prepare for three modes all with:

Energy/beam: 100 GeV/nucleon, diamond length:  $\sigma = 20$  cm

$$L_{\text{ave}}(\text{week})/L_{\text{ave}}(\text{store}) = 40 \%$$

- **Au-Au:** 56 bunches per ring with  $1 \times 10^9$  Au/bunch,  $\beta^* = 1\text{m}$ ,  $\varepsilon = 15 - 40 \pi \mu\text{m}$

$$L_{\text{peak}} = 14 \times 10^{26} \text{cm}^{-2}\text{s}^{-1}; L_{\text{ave}}(\text{store}) = 3 \times 10^{26} \text{cm}^{-2}\text{s}^{-1} [70 (\mu\text{b})^{-1}/\text{week}]$$

- **p↑-p↑:** 56(112) bunches per ring with  $1 \times 10^{11}$  p↑/bunch,  $\beta^* = 1\text{m}$ ,  $\varepsilon = 25 \pi \mu\text{m}$

$$L_{\text{peak}} = 8(16) \times 10^{30} \text{cm}^{-2}\text{s}^{-1}; L_{\text{ave}}(\text{store}) = 5(10) \times 10^{30} \text{cm}^{-2}\text{s}^{-1} [1.4(2.8)(\text{pb})^{-1}/\text{week}]$$

Beam polarization  $\geq 50 \%$

Acceleration test to 250 GeV

- **d-Au:** 56 bunches per ring with  $1 \times 10^9$  Au/bunch and  $1 \times 10^{11}$  d/bunch

Equal energy,  $\beta^* = 2\text{m}$ ,  $\varepsilon = 20 \pi \mu\text{m}$

$$L_{\text{peak}} = 5 \times 10^{28} \text{cm}^{-2}\text{s}^{-1}; L_{\text{ave}}(\text{store}) = 2 \times 10^{28} \text{cm}^{-2}\text{s}^{-1} [5 (\text{nb})^{-1}/\text{week}]$$

- New hardware installed and to be commissioned:

- All eight spin rotators for PHENIX and STAR